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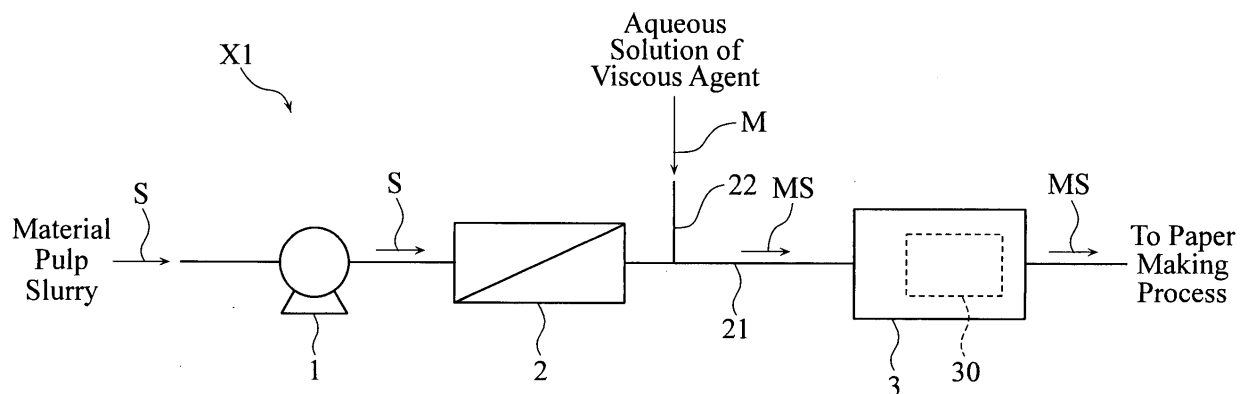
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(54) **PAPERMAKING METHOD AND PAPERMAKING SYSTEM**

(57) A papermaking method according to this invention is carried out using a paper machine provided with a head box (3) including a cell-structure manifold (30).

An aqueous solution (M) containing 0.03 to 0.4 wt % of viscous agent is added to a material pulp slurry (S), and the obtained mixed pulp slurry (MS) is introduced into the manifold (30).

FIG.1



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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a method and a system for performing papermaking using a paper machine provided with a head box including a manifold having a cell-structure.

BACKGROUND ART

10 **[0002]** Generally, a paper manufacturing process includes a pulp step for forming a material pulp slurry and a paper-making step for making paper from the pulp slurry. In the pulp step, a material pulp slurry is prepared by forming chips from wood and performing digestion, cleaning, picking, bleaching and so on. In the papermaking step, the material pulp slurry is supplied from a head box onto a wire element for dewatering, and then processes such as pressing and drying are performed to produce paper.

15 **[0003]** Various kinds of paper machines are known such as a cylinder machine, a Fourdrinier machine, a "tanmo" machine, a twin wire machine and a crescent former.

20 **[0004]** Generally, in the papermaking process using a cylinder machine, a large shearing force is not mechanically applied to the material pulp slurry in the head box, so that the pulp is not sufficiently dispersed. Thus, to produce paper having a relatively low basis weight such as tissue paper or toilet paper using a cylinder machine, a viscous agent for dispersing pulp is generally used. For instance, polyethylene oxide may be used as the viscous agent. Specifically, an aqueous solution of polyethylene oxide having the concentration of not more than about 0.01 wt % and appropriate viscosity may be added to the material pulp slurry. Owing to the pulp dispersion effect of the viscous agent added in the papermaking process, paper in which pulp fibers is uniformly dispersed and which has excellent formation is obtained.

25 **[0005]** Paper machines such as a Fourdrinier machine, a "tanmo" machine, a twin wire machine and a crescent former (hereinafter, these machines are referred to as "high-speed paper machines"), which have been developed to achieve a productivity higher than that of a cylinder machine and whose papermaking speed (wire traveling speed) is relatively high, include a manifold having a cell-structure and provided in a head box. In these machines, therefore, when the material pulp slurry passes through the manifold, a large shearing force is applied to the material pulp slurry, whereby the slurry is mechanically dispersed. Thus, by using a high-speed paper machine, low-basis-weight paper having excellent formation is obtained without using a viscous agent. However, as compared with the papermaking process using a cylinder machine, the time taken for dewatering on the wire element in the papermaking process using a high-speed paper machine is shorter, because of the higher papermaking speed. Further, since a viscous agent is not used, the dispersion of pulp on the wire element in a high-speed paper machine is inferior to that in a cylinder machine. As a result, although the productivity of a high-speed paper machine is higher than that of a cylinder machine, the quality of the obtained paper in terms of the formation is lower.

35 **[0006]** In recent years, competition for high quality paper is heating up in the field of papermaking, and a system capable of stably and easily making paper having excellent formation is demanded. Although improvement of paper machines is being carried out, studies of the addition of an agent for improving the pulp dispersion in a high-speed paper machine are not making much progress. A conceivable reason for this is that, even if such a viscous agent as a polyethylene oxide-based viscous agent, which is known to be relatively vulnerable to shearing, is used for a high-speed paper machine, the viscous agent is sheared due to a large shearing force applied within the head box. As a result, the viscosity is reduced, and hence, the effect of the viscous agent is reduced, so that the improvement of the formation like that obtained in the case of a cylinder machine is not expected.

40 **[0007]** Although the Patent Document 1 described below discloses a viscous agent to replace polyethylene oxide, only a cylinder machine is disclosed as the application.

45 **[0008]** Patent Document 1: JP-A 2000-290892

DISCLOSURE OF THE INVENTION

50 **[0009]** An object of the present invention, which is proposed in view of the above-described problems of the prior art, is to provide a papermaking method and a papermaking system capable of making paper having excellent formation even by the use of a high-speed paper machine by optimizing the concentration of a viscous agent solution to be added to the material pulp slurry.

55 **[0010]** To solve the above-described problems, the inventors of the present invention have studied changes in viscosity of aqueous solution of polyethylene oxide caused by shearing to find that the viscosity is hardly degraded by shearing when the aqueous solution has a concentration higher than a predetermined value. By applying this result of the studies to papermaking, the inventors have found that paper having excellent formation is obtained even by the use of a high-speed paper machine and achieved the present invention.

[0011] According to a first aspect of the present invention, there is provided a method of making paper using a paper machine provided with a head box including a manifold having a cell-structure. The method comprises the steps of adding an aqueous solution of a viscous agent having a concentration of 0.03 to 0.4 wt % to a material pulp slurry, and introducing a mixed pulp slurry containing the material pulp slurry and the aqueous solution of the viscous agent into the manifold.

[0012] With the above-described papermaking method, the pulp dispersion effect by a viscous agent is properly exhibited even in a paper machine which includes a cell-structure manifold in the head box. As a result, paper in which pulp fibers are uniformly dispersed and which has excellent formation is obtained. In this way, according to this papermaking method, a viscous agent is effectively used to improve the quality of paper.

[0013] Further, with the papermaking method according to the present invention, the use of a proper viscous agent reduces the defects such as the breakage of paper due to insufficient dispersion of pulp fibers, and hence, stable papermaking is possible. Thus, the yield of papermaking is enhanced, and the production efficiency is improved.

[0014] Preferably, the addition of the aqueous solution of the viscous agent is performed between the head box and a screen located closest to the head box. In this case, the pulp dispersion effect by the viscous agent is properly exhibited.

[0015] Preferably, the viscous agent is a polyethylene oxide-based viscous agent. Preferably, in this case, the viscous agent may comprise solely of polyethylene oxide.

[0016] According to a second aspect of the present invention, there is provided a papermaking system comprising a screen for removing impurities from a material pulp slurry, a paper machine provided with a head box including a manifold having a cell-structure arranged on a downstream side of the screen, and viscous agent adding means for supplying an aqueous solution of viscous agent having a concentration of 0.03 to 0.4 wt % into a pipe connecting the screen and the head box to each other.

[0017] Preferably, the viscous agent is a polyethylene oxide-based viscous agent.

[0018] Other features and advantages of the present invention will become more apparent from the detailed description given below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 shows the schematic structure of an example of papermaking system used for a papermaking method according to the present invention.

Fig. 2 is a longitudinal sectional view schematically showing a principal portion of a head box.

Fig. 3 is a perspective view showing an example of manifold.

BEST MODE FOR CARRYING OUT THE INVENTION

[0020] Fig. 1 schematically shows a papermaking system X1 used for a papermaking method according to the present invention. The papermaking system X1 mainly comprises a pump 1, a screen 2, a head box 3 and a piping connecting these members to each other for making paper from a material pulp slurry S by the papermaking method.

[0021] The pump 1 supplies the material pulp slurry S formed in a pulping step and containing pulp fibers to the screen 2 at a predetermined pressure.

[0022] The screen 2 removes impurities from the material pulp slurry S and makes the thickness of the material pulp slurry S uniform. When the material pulp slurry S is supplied to the screen 2, the material pulp slurry S passes through an extremely narrow space under a contact pressure from a non-illustrated roller. Thus, a relatively large shearing force is applied to the pulp fibers contained in the material pulp slurry S.

[0023] As shown in Fig. 2, the head box 3, which constitutes part of a paper machine, serves to eject a mixed pulp slurry MS onto a wire element 4 traveling endlessly. The mixed pulp slurry MS is obtained by adding a viscous agent P (which will be described later) to the material pulp slurry S. As shown in Fig. 3, the head box 3 includes a manifold 30 having a cell-structure made up of a plurality of pipes 31. By causing the mixed pulp slurry MS to flow through the manifold 30, the pulp fibers contained in the mixed pulp slurry MS are dispersed. Each of the pipes 31 includes an introduction end 31a and a discharge end 31b, and the cross sectional area of each pipe increases stepwise as progressing from the introduction end 31a toward the discharge end 31b. Examples of paper machine including a manifold like the manifold 30 include a crescent former, a twin wire paper machine and a Fourdrinier machine, which are high-speed paper machines whose papermaking speed is relatively high. The head box 3 includes a discharge opening 3a on the downstream side of the manifold 30. The mixed pulp slurry MS discharged from the manifold 30 is ejected onto the wire element 4 through the discharge opening 3a. In the illustrated embodiment, the discharge opening 3a is tapered toward the downstream side.

[0024] The screen 2 and the head box 3 are connected to each other via a pipe 21. A pipe 22 for adding a viscous

agent solution M is connected to the pipe 21. An example of viscous agent solution M to be added is polyethylene oxide-based aqueous solution.

[0025] When the papermaking system X1 having the above-described structure is operated, the material pulp slurry S is supplied to the screen 2 by the operation of the pump 1.

[0026] In the screen 2, unnecessary components such as impurities are removed from the material pulp slurry S, and a relatively large shearing force is applied to the pulp fibers contained in the material pulp slurry S. Thus, the initially agglomerated pulp fibers are dispersed to some degree.

[0027] The material pulp slurry S having passed through the screen 2 is introduced into the pipe 21. An aqueous solution of polyethylene oxide as the viscous agent solution M is added to the material pulp slurry S through the pipe 22. The aqueous solution is prepared in advance to have a polyethylene oxide concentration in the range of 0.03 to 0.4 wt %. For instance, the aqueous solution of polyethylene oxide may be prepared by dissolving powder of polyethylene oxide in water contained in a bath made of stainless steel while stirring the water using a stirrer provided at the bath. The material pulp slurry S and the viscous agent solution M are mixed within the pipe 21 to form the mixed pulp slurry MS, and the mixed pulp slurry MS is supplied to the head box 3.

[0028] In the head box 3, the mixed pulp slurry MS is introduced into the manifold 30 (the pipes 31). Since the cross sectional area of each pipe 31 is relatively small at a portion adjacent to the introduction end 31a, the mixed pulp slurry MS flows through this portion at a relatively high speed. Since the cross sectional area of the pipe increases stepwise as progressing toward the discharge end 31b, the speed of the flow of the mixed pulp slurry MS decreases stepwise. As a result, an eddy is generated within the pipe 31, whereby a relatively large shearing force is applied to the mixed pulp slurry MS. By the effect of the shearing force, the pulp fibers contained in the mixed pulp slurry MS are dispersed effectively. The viscous agent solution M is dispersed and mixed into the material pulp slurry S without being considerably deteriorated by the eddy generated in the pipe 31.

[0029] The mixed pulp slurry MS, in which the pulp fibers are properly dispersed by passing through the manifold 30 (pipes 31), undergoes a proper decrease of viscosity due to the shearing and is ejected from the discharge ends 31b onto the running wire element 4 through the discharge opening 3a. On the wire element 4, by the pulp dispersion effect of the viscous agent, the pulp fibers contained in the mixed pulp slurry MS are dispersed uniformly. Thereafter, the mixed pulp slurry MS is dewatered, and the process steps such as pressing and drying are performed to provide paper as a finished product.

[0030] In the papermaking method by the papermaking system X1 according to the present invention, the use of a polyethylene oxide-based viscous agent has good effect even when a high-speed paper machine incorporating a manifold having a cell-structure is used. Specifically, although a polyethylene oxide-based viscous agent has been conventionally used for papermaking by a cylinder machine, the use of a polyethylene oxide-based viscous agent for papermaking by a high-speed paper machine has been avoided because the reduction of viscosity is considerable and the pulp dispersion effect cannot be obtained. Under such circumstances, the inventors of the present invention sought the way to effectively use polyethylene oxide, which is stably produced industrially and has been used as an effective viscous agent for a cylinder machine, for a high-speed paper machine. As a result, the inventors have found that, when a polyethylene oxide-based viscous agent solution has a concentration (0.03 to 0.4 wt %) which is considerably higher than that (not higher than about 0.01 wt %) of a solution used for a cylinder machine, proper pulp dispersion effect is exhibited, and paper having excellent formation is obtained.

[0031] In the papermaking method of the present invention, it is preferable that the concentration of the viscous agent solution M to be added to the material pulp slurry S is 0.03 to 0.4 wt %, and more preferably, 0.03 to 0.2 wt %.

[0032] When the concentration of the viscous agent solution M to be added is not more than 0.03 wt %, the pulp dispersion effect of the viscous agent solution is deteriorated due to the reduction of viscosity by the shearing in the head box 3, and hence, the formation of paper is hardly improved. When the concentration of the viscous agent solution M to be added exceeds 0.4 wt %, the viscous agent solution M is not sufficiently mixed with the material pulp slurry S in the head box because of the high viscosity of the viscous agent solution M. As a result, the viscous agent solution partially agglomerates into a strip or a block, whereby the dispersion of the pulp fibers is hindered. In this case, failures such as paper breakage may occur, and stable papermaking may not be performed. Further, the produced paper may include defects such as specks and/or holes, whereby the quality of paper deteriorates.

[0033] However, when the concentration of the viscous agent solution M to be added is 0.03 to 0.4 wt %, the pulp dispersion effect is properly exhibited, and the defects such as specks and/or holes are prevented. Thus, with the papermaking method according to the present invention, paper having excellent formation is obtained, and thus, the improvement of the quality is achieved.

[0034] Further, with the papermaking method according to the present invention, the use of a proper viscous agent reduces the failures such as paper breakage due to insufficient dispersion of pulp fibers, and hence, stable papermaking is possible. Thus, the yield of papermaking is enhanced, and the production efficiency is improved.

[0035] In view of the pulp dispersion effect and the convenience in handling, it is preferable that the viscous agent (polyethylene oxide) used in the papermaking method according to the present invention has a viscosity average mo-

molecular weight of 3 million to 11 million, and preferably, 4 million to 9 million.

[0036] Although the amount of the viscous agent to be used depends on the kind of paper and is not limited to a particular value, the amount of 0.001 to 1.0 %, and preferably 0.01 to 0.5 % relative to the dry weight of the paper to be produced is considered effective.

[0037] The viscous agent solution M does not necessarily need to be added through the pipe 22 connected to the pipe 21 which connects the screen 2 and the head box 3 to each other. However, to properly exhibit the pulp dispersion effect by the viscous agent, it is preferable that the viscous agent be added at a position between the screen 2 and the head box 3, i.e., at a position downstream from the screen 2 and upstream from the head box 3. This is because, when the viscous agent solution M is added at a position upstream from the screen 2, the viscosity decreases by the shearing in the screen 2, so that the pulp dispersion effect by the viscous agent may not be exhibited.

[0038] The papermaking method according to the present invention is preferably applicable to the making of thin paper such as tissue paper or toilet paper having a basis weight of not more than about 60g/m², but is not limited thereto.

[0039] Examples of the present invention will be described below together with comparative examples.

[Example 1]

[Papermaking]

[0040] Paper was made from a material pulp slurry S using the papermaking system X1 according to the above-described embodiment. As the paper machine, a crescent former was operated to run at a speed of 800m/min to form tissue paper having a basis weight of 13 g/m². As the material pulp slurry S, a slurry of 0.15 wt % was prepared from NBKP (conifer pulp) and LBKP (broadleaf pulp) of 640 mlcsf beating degree (Canadian Standard Freeness) mixed at the ratio of 40 to 60 (weight ratio). As the viscous agent solution M, use was made of an aqueous solution of polyethylene oxide having a concentration of 0.07 wt %, which was prepared by dissolving polyethylene oxide (Tradename:PEO-27, Viscosity average molecular weight:7500000, available from Sumitomo Seika Chemicals Co., Ltd.) in water while stirring. In the papermaking process, the polyethylene oxide solution was supplied into the pipe 21 between the screen 2 and the head box 3. The amount of the viscous agent used was 0.1 % relative to the dry weight of the paper produced.

[Evaluation of formation of paper]

[0041] The paper made as above was examined for the improvement of formation. The formation was checked by visual inspection, and the result is given in Table 1. In Table 1, the mark 0 indicates that the formation is considerably improved, i.e., the pulp fibers are uniformly dispersed and holes and/or agglomeration of pulp fibers are hardly found, the mark Δ indicates that the improvement of formation is hardly found, and the mark x indicates that the formation is poor, i.e., holes and/or agglomeration of pulp fibers are found or a papermaking failure such as breakage of paper is caused.

[Example 2]

[0042] In Example 2, paper was made under the same conditions as those of Example 1 except that the aqueous solution of polyethylene oxide used as the viscous agent solution M had the concentration of 0.03 wt %. The examination result of the formation of the paper obtained by this example is also given in Table 1.

[Example 3]

[0043] In this example, a Fourdrinier machine was used as the paper machine. Specifically, the Fourdrinier machine was operated to run at a speed of 1100m/min to form tissue paper having a basis weight of 17 g/m². As the material pulp slurry S, a slurry of 0.12 wt % was prepared from NBKP and LBKP of 660 mlcsf beating degree (Canadian Standard Freeness) mixed at the ratio of 60 to 40 (weight ratio). As the viscous agent solution, use was made of an aqueous solution of polyethylene oxide having a concentration of 0.06 wt %, which was prepared by dissolving polyethylene oxide (PEO-27) in water while stirring. In the papermaking process, the polyethylene oxide solution was supplied into the pipe 21 between the screen 2 and the head box 3. The amount of the viscous agent used was 0.15 % relative to the dry weight of the paper produced. The examination result of the formation of the paper obtained by this example is also given in Table 1.

[Example 4]

[0044] The same paper machine as that of Example 3 was operated to run at a speed of 1000m/min to form tissue

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paper having a basis weight of 15 g/m². As the material pulp slurry S, a slurry of 0.12 wt % was prepared from NBKP and LBKP of 660 mlcsf beating degree (Canadian Standard Freeness) mixed at the ratio of 60 to 40 (weight ratio). As the viscous agent solution, use was made of an aqueous solution of polyethylene oxide having a concentration of 0.15 wt %, which was prepared by dissolving polyethylene oxide (PEO-27) in water while stirring. In the papermaking process, the polyethylene oxide solution was supplied into the pipe 21 between the screen 2 and the head box 3. The amount of the viscous agent used was 0.15 % relative to the dry weight of the paper produced. The examination result of the formation of the paper obtained by this example is also given in Table 1.

[Comparative Example 1]

[0045] In this comparative example, paper was made under the same conditions as those of Example 1 except that the aqueous solution of polyethylene oxide used as the viscous agent solution M had a concentration of 0.01 wt %. The examination result of the formation of the paper obtained by this comparative example is also given in Table 1.

[Comparative Example 2]

[0046] In this comparative example, paper was made under the same conditions as those of Example 3 except that the aqueous solution of polyethylene oxide used as the viscous agent solution M had a concentration of 0.5 wt %. The examination result of the formation of the paper obtained by this comparative example is also given in Table 1.

[Comparative Example 3]

[0047] In this comparative example, paper was made under the same conditions as those of Comparative Example 1 except that a cylinder machine was used as the paper machine. The examination result of the formation of the paper obtained by this comparative example is also given in Table 1.

[Table 1]

	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparative Example 2	Comparative Example 3
Paper machine	Crescent former		Fourdrinier		Crescent former	Fourdrinier	Cylinder machine
Target Paper	tissue paper						
Paper making speed (m/min)	800	800	1100	1000	800	1100	800
Basis weight (g/m ²)	13	13	17	15	13	17	13
Viscous agent concentration (wt/%)	0.07	0.03	0.06	0.15	0.01	0.5	0.01
Viscous agent amount (relative to dry weight of paper: %)	0.1	0.1	0.15	0.15	0.1	0.15	0.1
Formation improvement	○	○	○	○	Δ	×	○

[0048] Since the viscous agent solution M used in Examples 1-4 had a high concentration within a predetermined range, the formation of the paper was better than that of the paper formed using a viscous agent solution M of a lower concentration like Comparative Example 1. Herein, the concentration (0.01 wt %) of the viscous agent solution M used in the Comparative Example 1 is close to the upper limit of the concentration range (not more than about 0.01 wt %) of polyethylene oxide solution conventionally known as appropriate for use for papermaking (using a cylinder machine).

[0049] Since the viscous agent solution M used in Comparative Example 2 had a concentration higher than the

predetermined range, the viscous agent solution M agglomerated in the papermaking process due to the high viscosity to cause failures such as the breakage of the paper.

5 **Claims**

1. A method of making paper using a paper machine provided with a head box including a manifold having a cell-structure, the method comprising the steps of:

10 adding an aqueous solution of a viscous agent having a concentration of 0.03 to 0.4 wt % to a material pulp slurry; and
introducing a mixed pulp slurry containing the material pulp slurry and the aqueous solution of viscous agent into the manifold.

15 2. The papermaking method according to claim 1, wherein the addition of the aqueous solution of viscous agent is performed between the head box and a screen located closest to the head box.

3. The papermaking method according to claim 1, wherein the viscous agent is a polyethylene oxide-based viscous agent.

20 4. A papermaking system comprising:

a screen for removing impurities from a material pulp slurry;
a paper machine provided with a head box including a manifold having a cell-structure arranged downstream
25 from the screen; and
a viscous agent adder for supplying an aqueous solution of a viscous agent having a concentration of 0.03 to 0.4 wt % into a pipe connecting the screen and the head box to each other.

30 5. The papermaking system according to claim 4, wherein the viscous agent is a polyethylene oxide-based viscous agent.

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FIG.1

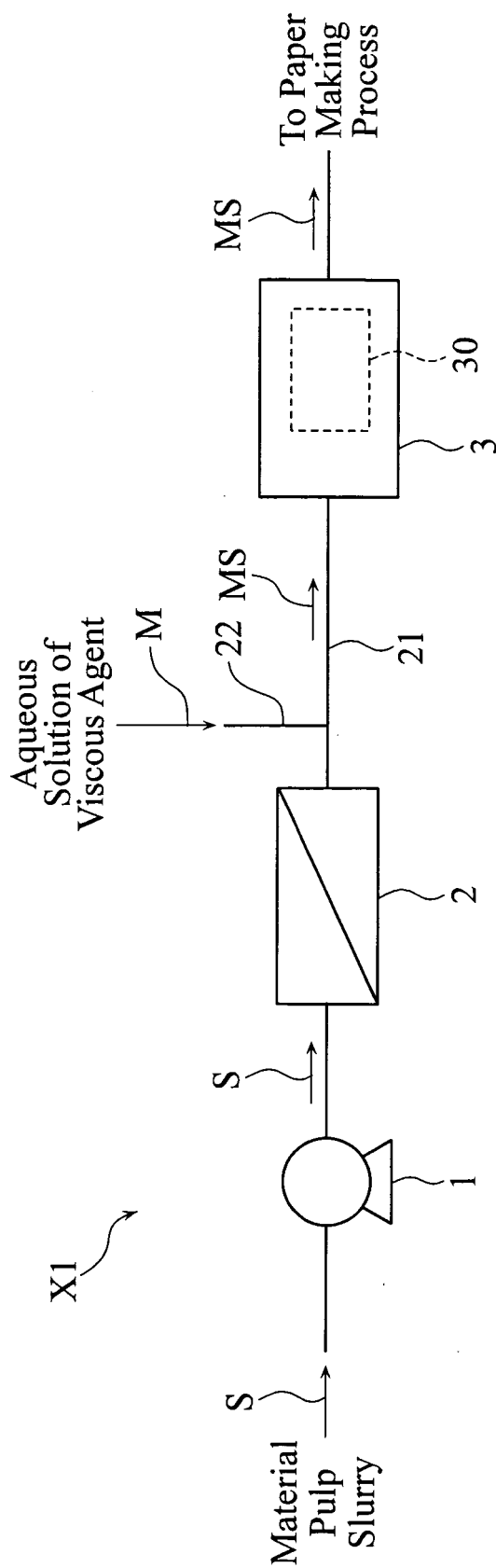


FIG.2

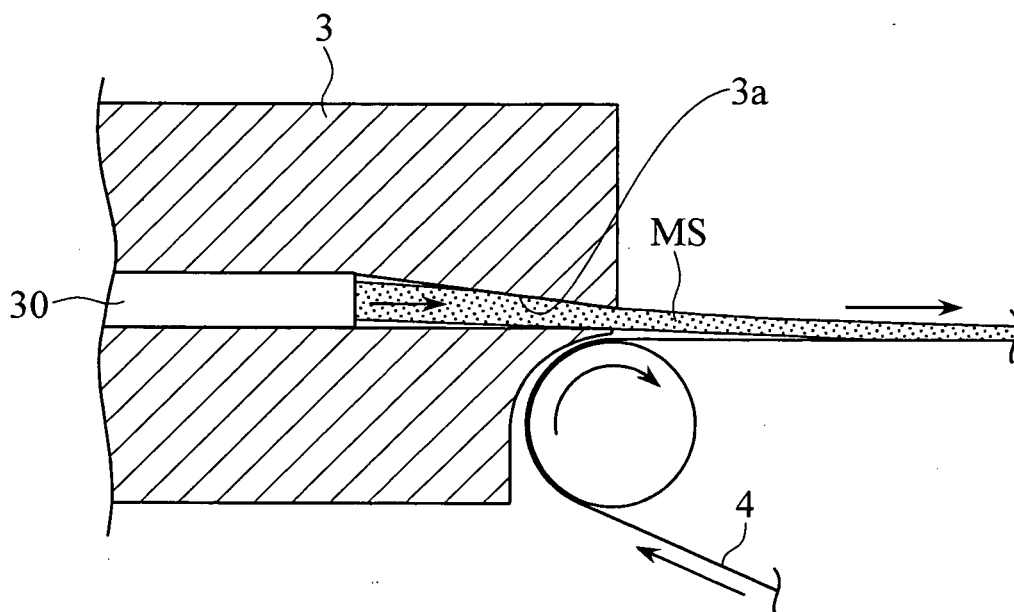
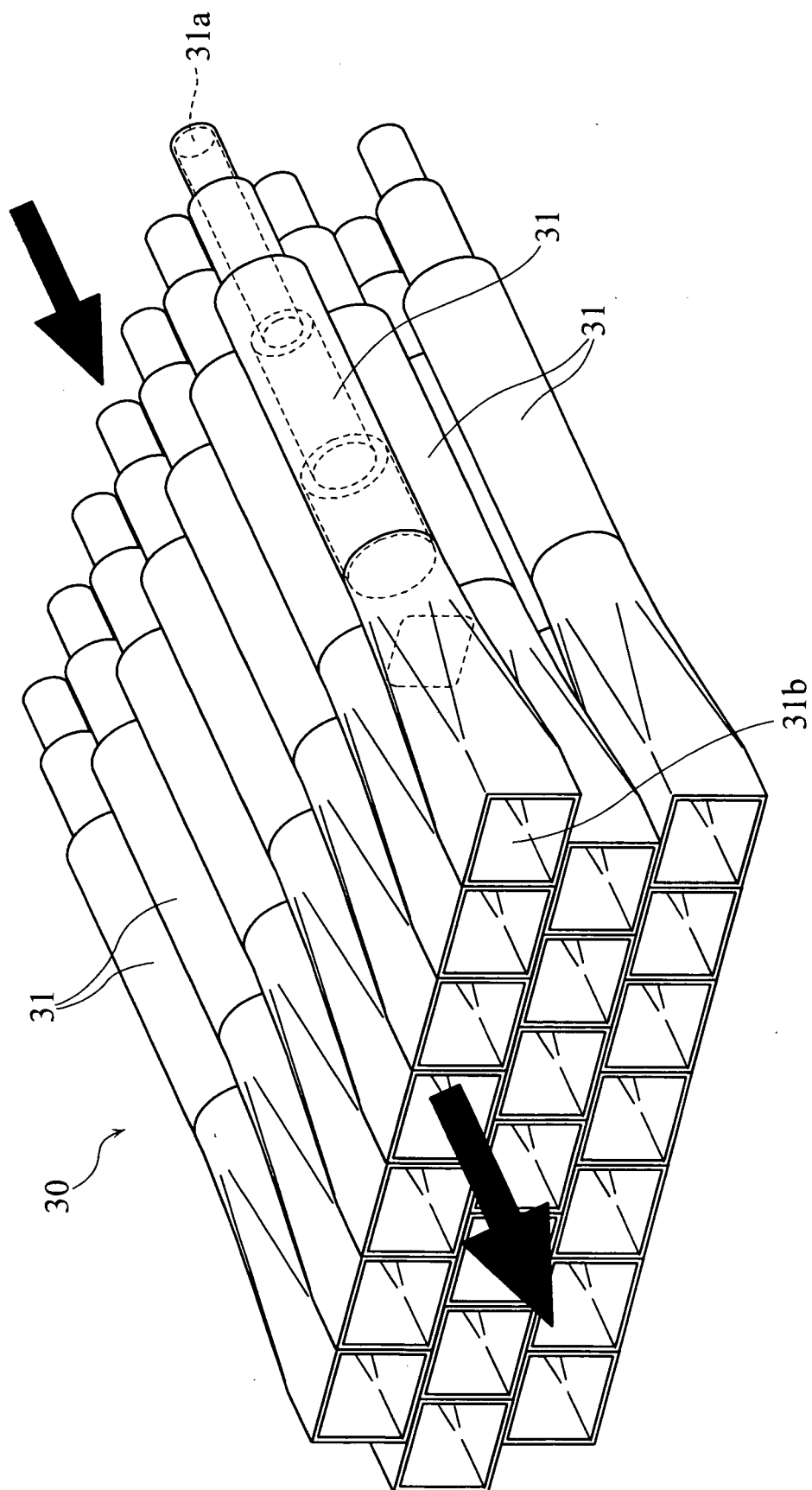


FIG.3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/321007

A. CLASSIFICATION OF SUBJECT MATTER

D21H21/06(2006.01) i, D21H17/53(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

D21H21/06, D21H17/53

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2005-126880 A (Dia-Nitrix Co., Ltd.), 19 May, 2005 (19.05.05), Par. Nos. [0001], [0026]; table 3 (Family: none)	1, 3-5 2
Y A	JP 2005-154978 A (Dia-Nitrix Co., Ltd.), 16 June, 2005 (16.06.05), Par. Nos. [0001], [0026]; table 3 (Family: none)	1, 3-5 2
Y A	JP 2004-517229 A (Metso Paper, Inc.), 10 June, 2004 (10.06.04), Par. Nos. [0009], [0017]; Fig. 1 & US 2004/60680 A1 & EP 1346104 A & WO 02/57542 A1	1, 3-5 2

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search
16 January, 2007 (16.01.07)Date of mailing of the international search report
30 January, 2007 (30.01.07)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/321007

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 06-146189 A (Mitsubishi Heavy Industries, Ltd.), 27 May, 1994 (27.05.94), Claim 1; Par. No. [0009]; Fig. 1 (Family: none)	2

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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